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Memorandum
From the office of
Commissioner Bob Burns
Arizona Corporation Commission
1200 W. WASHINGTON
PHOENIX, ARIZONA
(602) 542-3682

Arizona Corporation Commission

DOCKETED

JUL 29 2014

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TO: Docket Control

DATE: July 29, 2014

FROM: Commissioner Bob Burns

SUBJECT: Emerging Technologies in Energy, Docket No. E-00000J-13-0375

ORIGINAL

The agenda and presentations from the July 28, 2014 Emerging Technologies Workshop have been docketed. If for some reason you cannot access eDocket, please contact my Executive Aide, Jessica Perry, to receive copies of the presentations.

Original and thirteen (13) copies of the agenda and presentations filed this 29th day of July, 2014, with:

Docket Control
Arizona Corporation Commission
1200 West Washington Street
Phoenix, Arizona 85007

Copies of the memo mailed this 29th day of July, 2014, to:

Service List

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ARIZONA CORPORATION COMMISSION
DOCKET CONTROL

REVISED NOTICE
SPECIAL OPEN MEETING
OF THE ARIZONA CORPORATION COMMISSION

Commission Workshop on Emerging Technologies
Docket No. E-00000J-13-0375

DATE: Monday, July 28, 2014

START TIME: 9:00 a.m.

Arizona Corporation Commission
Hearing Room One
1200 W. Washington Street
Phoenix, Arizona 85007

This shall serve as notice of a special open meeting of the Arizona Corporation Commission at the above location for consideration, discussion, and possible vote of the items on the following agenda and other matters related thereto. Please be advised that the Commissioners may use this open meeting to ask questions about the matters on the agenda; therefore, the parties to the matters to be discussed or their legal representatives are requested, though not required, to attend. The Commissioners may move to executive session, which will not be open to the public, for the purpose of legal advice pursuant to A.R.S. §§ 38-431.03.A.2, 3 and/or 4 on the matters noticed herein. The Commissioners may also move to executive session, which will not be open to the public, for other purposes specified in A.R.S. §§ 38-431.03, including discussions, consultations or considerations of Commission personnel and salary matters, on matters noticed herein.

The Arizona Corporation Commission does not discriminate on the basis of disability in admission to its public meetings. Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, as well as request this document in an alternative format, by contacting Shaylin A. Bernal, phone number (602) 542-3931, E-mail sabernal@azcc.gov. Requests should be made as early as possible to allow time to arrange the accommodations.

Jodi Jerich
Executive Director

Agenda

Welcome & Opening Remarks

Presentations:

1. Tucson Electric Power
 - a. Jim Taylor
Senior Director of Engineering & Operations Technology
“TEP’s Distribution Automation Strategy”

2. Arizona Public Service
 - a. Brad Albert
General Manager, Resource Management
“Wholesale Market Evolution and the Energy Imbalance Market”
 - b. Scott Bordenkircher
Director, Technology Innovation and Integration
“Technologies for a Flexible Grid”
3. Stealth Software
 - a. Gerard Warrens
CEO
“The Role of Utilities in Connected Cities”
4. Arizona State University
 - a. Dr. Sayfe Kiaei
Professor of Electrical, Computer & Energy Engineering
Director, Connection One NSF Center
“Alternative Energy Integration with the Grid”

Wrap-Up & Closing Remarks

Distribution Automation Strategy

Jim Taylor

Senior Director

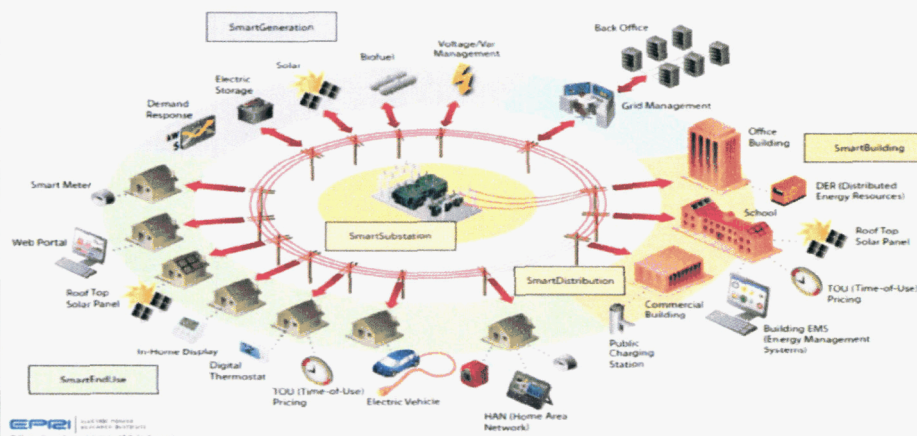
T&D Engineering and Operations Technology

Tucson Electric Power

July 28, 2014



Technological Advancements



New technologies are available and are being developed for all facets of the electrical grid

Short Term (Next 5 years)

- o **Short term strategy**
 - Ability to operate distribution similar to transmission system
- o **Short term goals**
 - Modernize distribution feeders
 - Implement automation technologies
 - Modify distribution control and operations functions
 - Develop operating tools for incorporating generation into distribution system
 - Deploy sensors to strategic assets
- o **“Implement at the speed of value”**



3

Foundational Need

- o **Communications**
 - Network of networks
 - Device to device
 - Device to collector
 - Backhaul infrastructure



4

Meter Strategy

- o **AMR Meter Deployment**

- Data gathered via fixed network
- Data stored securely in meter data management system

- o **Strategy Capabilities**

- Interval data collected and stored for all customers
- Use interval data to calculate different rate billing determinates
- Ratemaking capabilities
- Service outage and restoration messages



5

Automation Technologies

- o **Demand Response/Energy Efficiency**

- Volt/Var pilot projects

- o **Pilot Objectives**

- Optimize distribution equipment usage to provide energy savings to customers
- Test options to use voltage reduction for demand reduction



6

Modernize Distribution Feeders

o Remote Distribution Line Switching

- Strategically implement distribution switches that can be controlled remotely.
 - Limit truck rolls
 - Support automated outage restoration in future

o Distribution Feeder Status

- Pilot Grid Advisor project
 - Grid awareness
 - Provide distribution feeder information
 - Real-time indication of outages, faults and other events



7

Distribution Control & Operations

o Distribution System Awareness

- Distribution Management System (DMS)
 - Single view of the distribution system
 - Alarm management
 - Remote operation of distribution switches
 - Operator studies ("what-if" scenarios for switching)
 - Phase balancing studies
 - Control of volt/var system



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Distribution Control & Operations

- o Data as an Asset
 - PI server as repository for system data
 - PI screens for real-time maintenance data viewing and alarming
 - DG solar data viewing
 - Solar radiance forecasting



Technologies for a Flexible Grid

ACC Workshop on Emerging Technologies

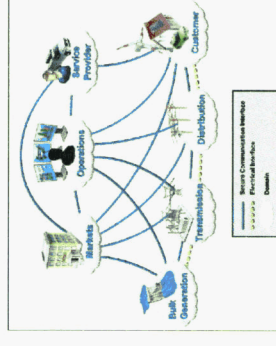
Scott Bordenkircher
Director, Technology Innovation & Integration
July 28, 2014



Why a Flexible Grid?

- Optimize Reliability & Performance
- Empower Customers
- Enable Alternative Energy & Technologies

“Increased visibility, operational flexibility, and organizational adaptability”

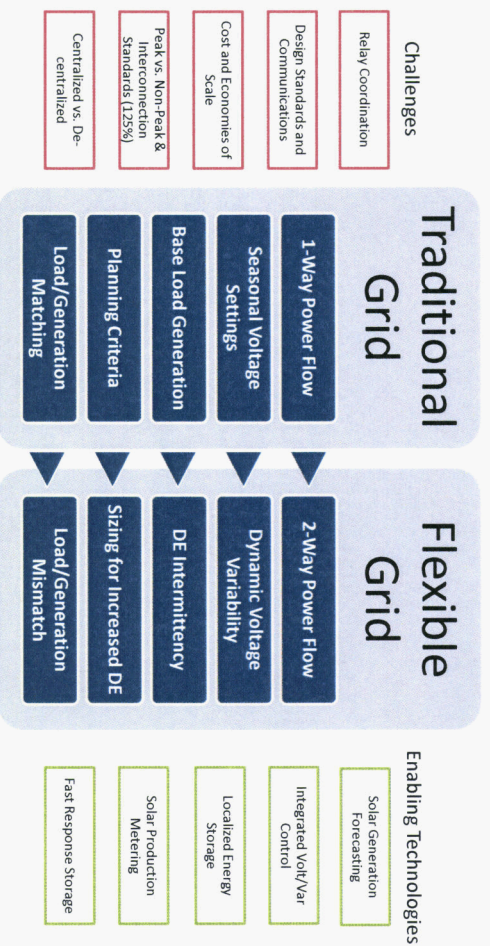


7/25/2014



Grid Evolution

Flexible grid needs to address many items that the traditional grid was never designed to handle...

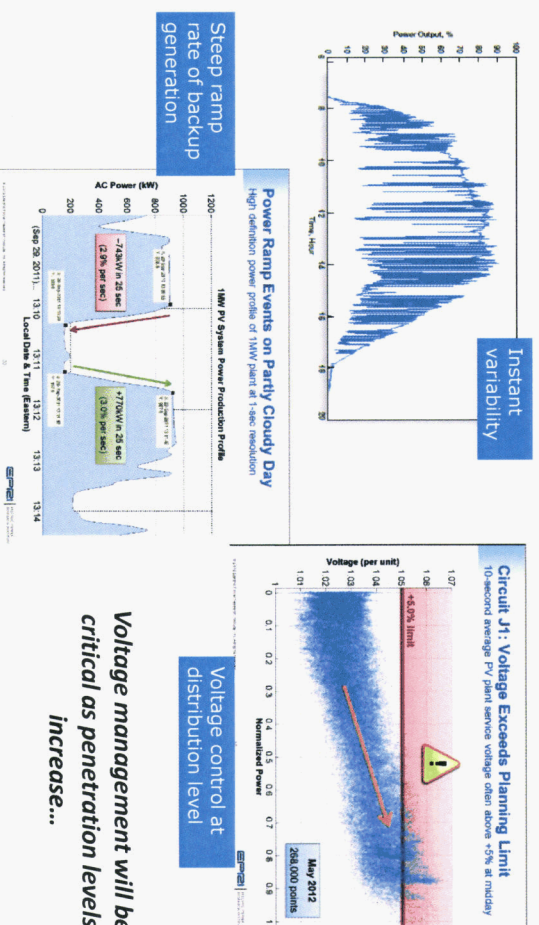


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Operational Challenge: PV High Pen



Voltage control at distribution level

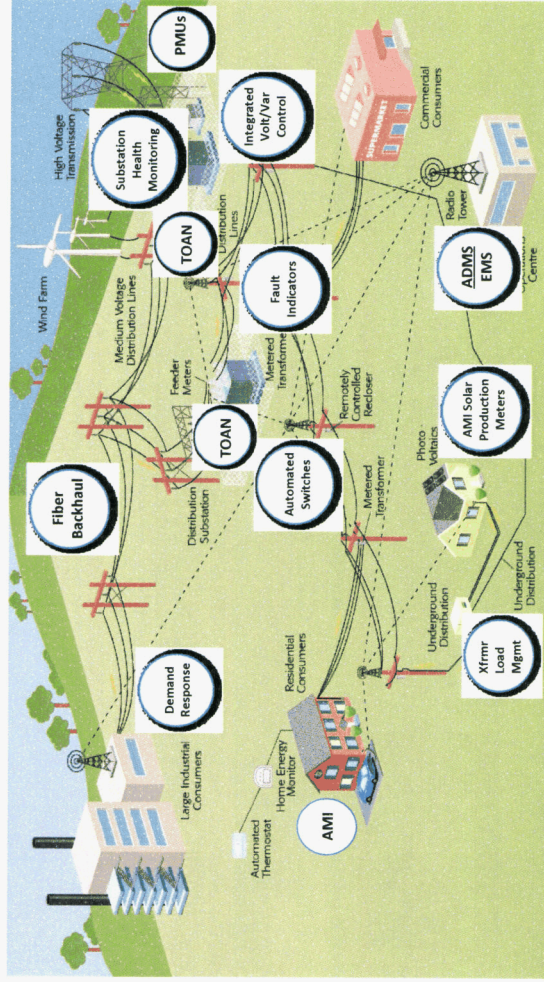
Voltage management will be critical as penetration levels increase...

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Flexible Grid Technology Landscape

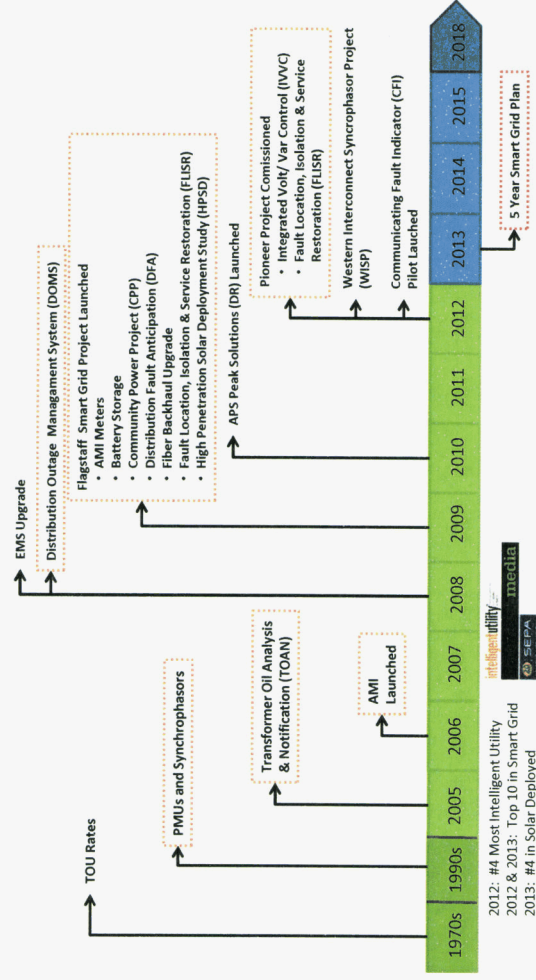


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History of the Flexible Grid at APS



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Foundational Blocks of Flexible Grid

EMS/ADMS

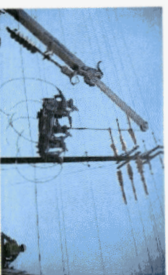
Highly advanced operational platforms



Status: Currently connected

Signal strength: 26dB

Duration: 18 hours
Access point: 00:18:0a:31:07:21
Channel: 149 - 5.745 GHz (11n, 40MHz channel)
Packets: 53899 sent, 24520 received
Data: 6.9 MB sent, 22.6 MB received



Communicating Devices

Robust system health/
situational awareness; both
local and regionally

Automated Switching

Remote operation for
approximately half of the
distribution system

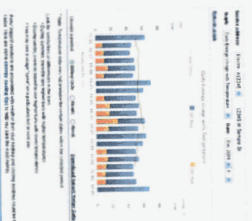
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Advanced Metering Infrastructure

- Current deployment ~ 1,250,000 meters
- More than 1,600,000 truck rolls avoided to date
 - Remote Connects/Disconnects
 - Rate Changes
 - Reduced potential for motor vehicle accidents
 - Lower gasoline consumption
- Greater customer information and flexibility
- Enables additional customer program offerings
 - Pick-a-Due Date
 - Pre-Pay Pilot
 - Home Energy Information Pilot
- Operational and planning benefits
 - Transformer Load Management
 - Voltage Management
 - Outage Management

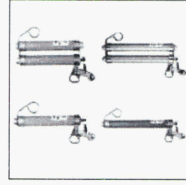


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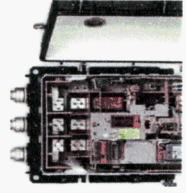
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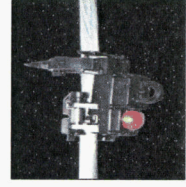
Flexible Grid Technologies



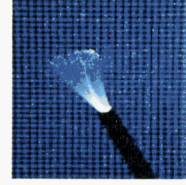
Fire Mitigation



Network SCADA Protectors



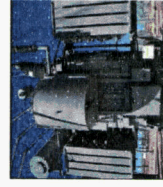
Communicating Fault Indicators



Communication Backhaul



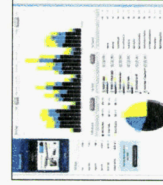
Automated Switches



Substation Health Monitoring



Integrated Volt VAR Control



Advanced Analytics

Utility Technologies

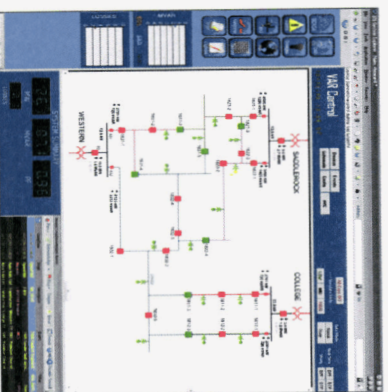
- Enabling Technologies
 - Energy Management System (Transmission)
 - Advanced Distribution Management System (Distribution)
 - Communications Infrastructure
 - Advanced Analytics



ADMS: Major Enabling Operational Platform

Implement an Advanced Distribution Management System to expand situational awareness and remote control capabilities

- Outage Management
 - o Trouble Call Management
 - o Crew Management
 - o Outage Notification
- Distribution Control and Awareness
 - o Breaker Control
 - o Remote Control of Feeder Devices
 - o Situational Awareness of Distribution Equipment
- Advanced Applications
 - o Load Flows (balanced and unbalanced)
 - o Fault Location
 - o Training Simulator
 - o Event Playback
 - o Restoration Switching Analysis



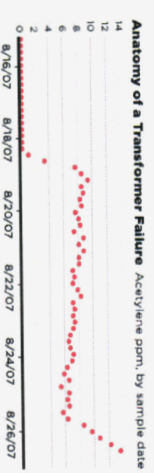
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Utility Technologies

- Predictive/Preventative
 - Transformer Oil Analysis Notification (TOAN)
 - Substation Health Equipment Monitoring
 - Distribution Asset Monitoring
 - Distribution Fault Anticipation
 - Phasor Measurement Units



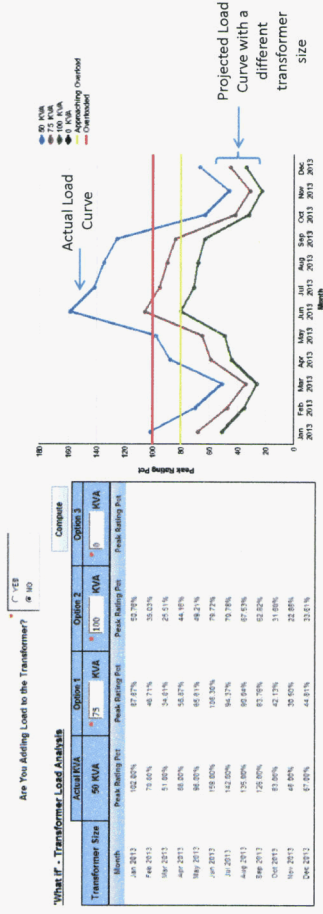
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Transformer Load Management Tool

Analytics application leveraging AMI, CIS and GIS data to proactively manage transformer overloaded conditions, reduce number of transformer failures and unplanned outages



"What-If" analysis allows user to perform scenarios to right-size transformers based on additional load and actual transformer load information

Use cases:

- EV assessment
- Distribution Operations
- Distribution Planning
- Supply Chain

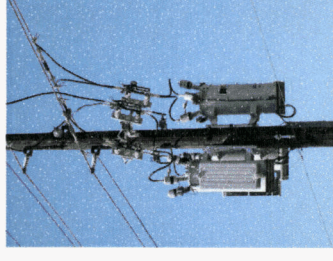
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Utility Technologies

- Restorative/Post-Event
 - Self-Isolating/Self-Healing Feeders
 - Distribution Automation (supervisory control)
 - Outage Notification
 - Network Protectors
- Performance Optimization
 - Battery Storage
 - Smart Inverters
 - Integrated Volt/Var Control
 - Conservation Voltage Reduction



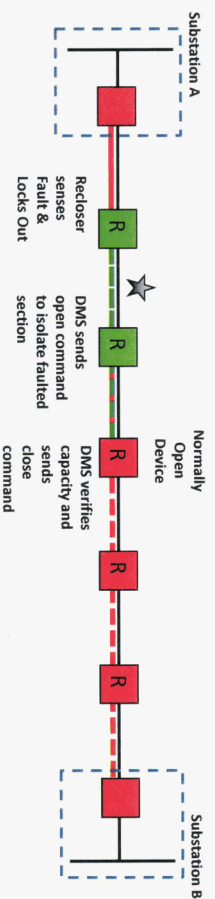
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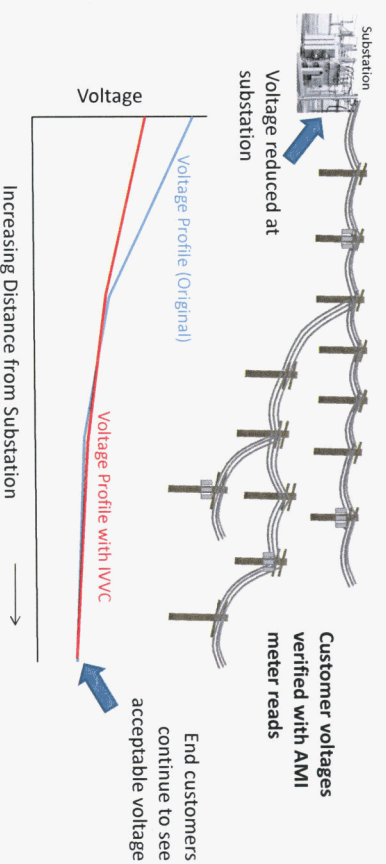
Distribution Automation: The “Self-Isolating/Healing” Grid

Fault Isolated and Power Restored to Non-faulted Line
Reclosers are added to divide feeder backbone into remotely switchable sections
Customer Impact Reduced by 2/3

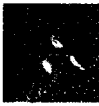






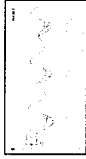

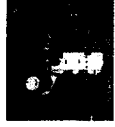





Voltage Drop – IVC Impact

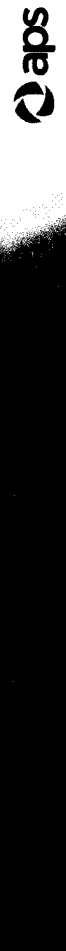
Flatten voltage across the feeder, mitigate voltage injections, and ensure voltage standards are met



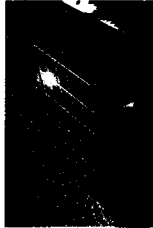




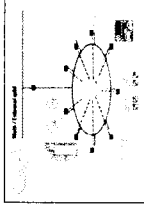
APS 5-Year Deployment Plan

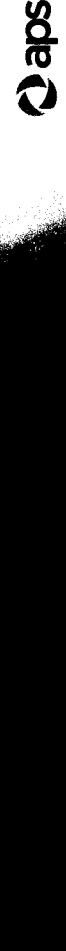
 Integrated Volt/VAR Control (IIVC)	 Advanced Distribution Management System	 Network Protectors	 Energy Management System (EMS) Upgrades	 Synchrophasors
 Transformer Load Management Tool	 Voltage Visualization	 Renewable Feeder Tool	 Supervisory Controlled Switches	 Substation Health Monitoring
 Communicating Fault Indicators (CFI)	 Strategic Fiber	 AMI		

To date deployment:	AMI – >1.2 Million Devices TOAN – 47 EHV Substations FLISR – 13 Feeders	CFI – 231 Devices on 25 Feeders IIVC – 6 Feeders Synchrophasors – 15 Devices
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Emerging Technologies

 Rooftop Solar	 Battery Storage	 Home Energy Management
 Electric Vehicles	 Fuel Cells	 Microgrids



What's Next?

- Distributed solar generation will continue to grow at an exponential rate
- Microgrids will become a valuable part of energy and grid reliability mix
- Energy storage important but will only be cost effective in niche circumstances for the next 5 years
- Electric Vehicles will continue to slowly infiltrate transportation
- Home Energy Management will continue to permeate as the market develops



Questions



Scott Bordenkircher
Director, Technology Innovation & Integration
Scott.Bordenkircher@aps.com



Wholesale Market Evolution and the Energy Imbalance Market

July 2014



Outline

- Wholesale market evolution
- Will an EIM affect how APS currently transacts in the market?
- What is an EIM, and how does it work?
- EIM Questions
- SVERI Group
- APS Points of View

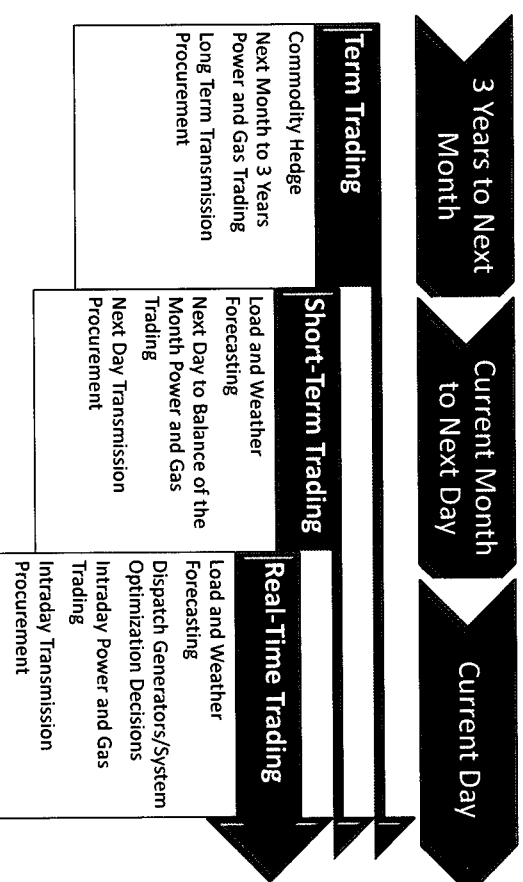
Wholesale Markets

- Traditional real-time transactions have rigidities
 - Typical block sizes of MWs
 - Smallest trade window is hourly
- These rigidities, combined with greater penetration of variable renewable generation, have produced a landscape where creative solutions are now being pursued to capture additional efficiencies



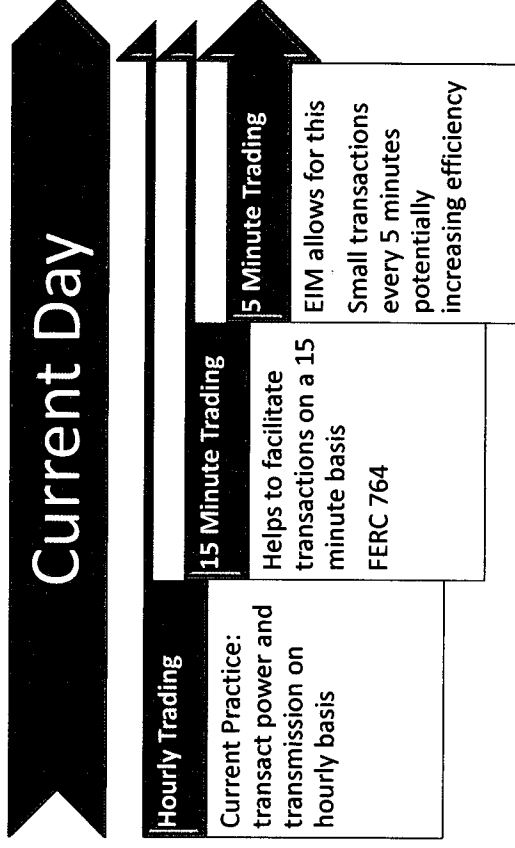
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APS Trading Process Spectrum



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Wholesale Market Evolution



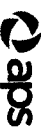
What is an Energy Imbalance Market?

- An automated system that allows transactions to occur in 5 minute intervals
 - The system loads generators to balance the supply of electricity with demand over a broad footprint
 - Could lead to increased efficiency
 - Could provide benefits for integrating higher penetrations of variable energy resources

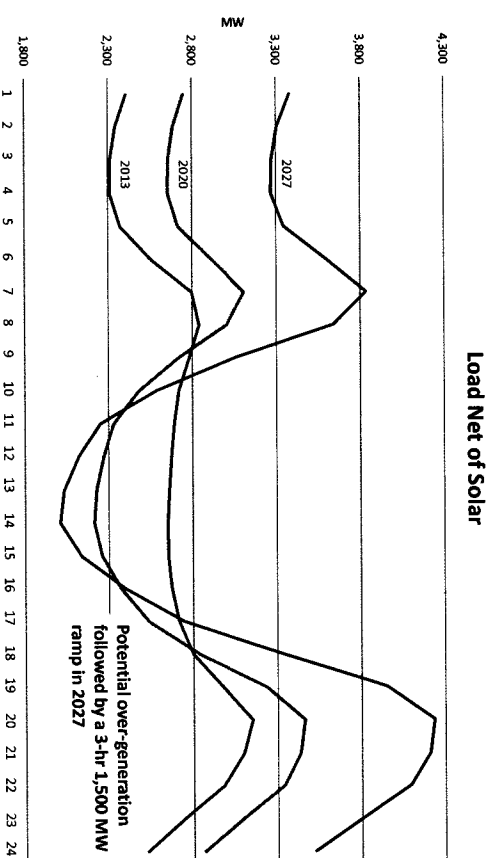
EIM – Renewable Integration

- Will participants will be able to solve renewable integration issues through the EIM?
 - Yes and No
 - EIM works to manage variability over a very short time frame but is not designed to aid in large ramping needs
 - Every participating Balancing Authority must still comply with WECC and NERC standards
 - Must have enough resources to meet load w/out EIM
 - Checks in place to ensure participants follow rules
 - Penalties for noncompliance

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APS Typical March Load after Solar Gen Adjustments



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EIM – System Reliability

- Does EIM improve overall system reliability?
 - Yes and No
 - Increased visibility and information sharing across a large footprint provides reliability benefits
 - Balancing Authorities still have to adhere to reliability standards and have sufficient resources to meet load and ramp requirements

EIM – Generation Control

- Does participation mean handing over control of generation to the EIM Operator?
 - No
 - Participants decide which generators are participating resources, including the possibility of no generation bid in at times

EIM - Savings

- How much savings will participation in EIM provide?
 - Savings need to be quantified
 - Modeling real world EIM outcomes is extraordinarily difficult
 - Many assumptions must be made regarding:
 - Transmission business practices
 - Hydro resource participation
 - Penalties, added fees and unforeseen costs which can't be modeled

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EIM Participant Activities

- PacifiCorp has committed to join the CAISO EIM
 - First participant to join in West
 - "Go-live" date October 1, 2014
- NV Energy also joining
 - Aiming for an Autumn 2015 start date

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Southwest Variable Energy Resource Integration (SVERI) Group

- Members include: APS, PNM, SRP, IID, TEP, WAPA, AEPCO, EPE
- Purpose is to be forward thinking in how increased renewable generation will be handled across the combined footprint of the group
- Not focusing on EIM, but rather how the group's specific renewable portfolio may best be managed

SVERI Group

- Current Initiatives:
 - Created Website that posts cumulative generation and renewable data
 - Increases system operator visibility because renewable generation across the entire SVERI footprint is seen
 - Allows analysts to further study how renewables can and will impact the collective footprint
 - Future enhancements to the wholesale market or SVERI member cooperation will be explored after analysis conducted

APS Points of View

- Participation in an EIM could complement APS current trading practices
- Provides the potential to lower APS customer cost
 - Because EIM is in its initial stages, there are numerous details that need to be sorted out
- APS is reasonably well positioned to effectively manage the future influx of renewable generation
 - Diversification of renewable types/locations
 - Flexible generation additions

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APS Approach

- Currently evaluating EIM and its potential impacts to APS and its customers
- Participate in CAISO EIM processes
 - Transitional Governance Committee meetings
 - Ongoing stakeholder processes
- Closely monitor PacifiCorp EIM participation outcomes

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The Role of Utilities in Connected Cities



Gerard Warrens
CEO
Stealth Software
E. gerard.warrens@stealth-soft.com

Industry Drivers & Trends

Exponential Data Growth

Rising concerns about data security, information protection, and management

Supply-side constraints

Demand exceeding supply; carbon legislations; renewables mandates

Aging Workforce

Knowledge retention issues – 30% of the workforce retiring in the next five years

Antiquated Infrastructure

Most equipment is past its current life expectancy

Public Safety

Grid vulnerability to acts of terrorism and natural disasters

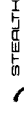
Regulatory Concerns

Increase urgency to “protect the grid”
NERC-CIP; FERC; EPA; PUCs; data retention, energy efficiency; renewables

Economic loss

Outages cost US Business >\$ 100B on average per year

Source: McKinsey, Gartner, Forrester, EPRI, DOE, EMC



Smart Grid, IT Spending, Urbanization

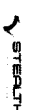
- At its core, the smart grid is a system of two-way communication between end-customer and utility.
- The smart grid is the beginning of IT and Operational Technology convergence.
- The operations side of the utility is becoming very IT oriented
- IT spending among US utility industry has grown 11 per cent from 2010 year over year, compared to an average of 2.6 per cent in all other industries.
- Cities - 75% of energy produced is consumed by cities
- Urbanization - 50% of the world's population lives in cities today and 70% of the global population is expected to live in urban environments by 2050

Source: Frost & Sullivan analysis, Stealth Software



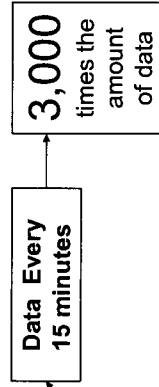
Information is a Key Enabler

- Information will:
- Power new pricing mechanisms
 - Enable new customers programs like demand response and energy rebates via usage and payment behavior analyses
 - Facilitate operational efficiencies via more accurate load analyses and forecasting to reduce the frequency of firing peak plants
 - Provide more advanced guidance on building and placement of renewable generation
 - And more...



How much Information?

Millions of new intelligent devices installed along the grid and a new network infrastructure to transmit the data from the end points back to the utility's data center.



250 Million
new Smart Meters
Globally by 2015

US target **40 Million**

800 TB/Year
Home Devices

Advanced Metering Infrastructure

Part of an Advanced Metering Infrastructure (AMI):

- Significant extension of traditional revenue-cycle-oriented metering systems
- Enterprise function supporting multiple uses of consumption data
 - Asset Management – optimal network configuration and loss minimization
 - Commodity Management – load profiling and forecasting
 - Customer Relationship Management – customer segmentation based on static load profiles and response to variable pricing signals

380 TB/Year
by full AMI deployment

Vendor and Information Storage Platform Independent

Source: EMC, Stealth Software

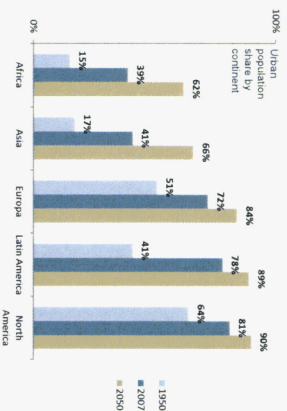


Source: EMC, Stealth Software



Urbanization Challenge

50% of the world's population lives in cities today and 70% of the global population is expected to live in urban environments by 2050



Source: UN Population Division, World Urbanization Prospects

•50% of the world's GDP is produced in Cities with over 750k population

•75% of energy produced is consumed by cities

•80% of the world Co2 Emissions are from cities

Key Drivers

Growth/ Development/ Acuteness of:

- Terrorism, Crime and Emergencies
- Road congestion
- **Energy consumption**
- Gas emission and waste contamination
- Demographics

Need/ requirement for:

- Clean water and air storage
- Effective transportation networks
- **Reliability and efficiency of energy**
- Safety and Security
- Connectivity and Communication

Ability and necessity to transfer current approach of urbanization development to the format of Safe and Smart Cities

Source: Frost & Sullivan analysis



How SMART drives SAFE and Vice-Versa

SMART Buildings: At least 50% of Buildings Will be Green and Intelligent Built with BIPV, 20% of the Buildings Will Be Net Zero Buildings.

SMART Technology: Intelligent Communication Systems Connecting Home, Office, iPhone and Car on a Single Wireless IT Platform.

Satellite Towns: Main City Centre Will Merge with Several Satellite Towns to Form ONE BIG MEGA CITY.

Source: Google Images

SMART Mass Transport: Multimodal Transport Hubs Providing Excellent Air, Rail, Road Connectivity to Other Mega Cities.

SMART Energy: 20% of Energy Produced in the City Will be Renewable (Wind, Solar etc).

SMART GRID: Infrastructure to Enable Real Time Monitoring of Power Flow and Provide Energy Surplus Back to the Grid.

SMART Cars: At least 10% of Cars will be Electric Vehicles. Free Fast Charging Stations at Every Half Mile.

Source: Frost & Sullivan analysis

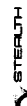


SharePoint: a collaboration and workflow platform – Why?

- 2013: 673 M users
- 2017: 842 M users – ~ 10% of the world population
- Easy to deploy customer facing applications and enterprise applications
- 87% of enterprise accounts and government agencies are using SharePoint, including all the major cities.
- 750,000 people developing, integrating, deploying SharePoint applications, including Energy Sector applications.

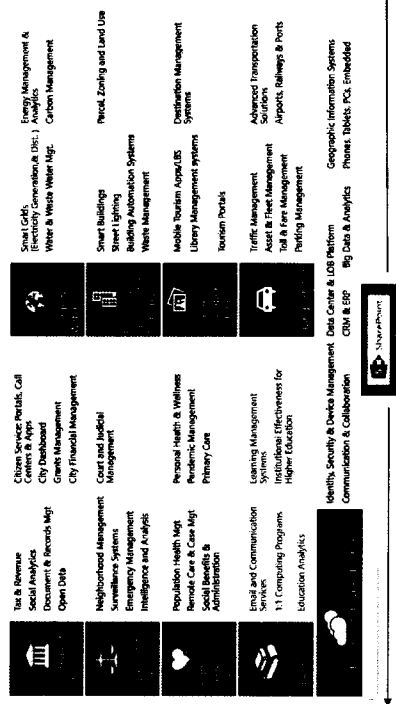
		2013	2014	2015	2016	2017
M Users	North America	242	254	259	267	286
	% North America	36%	36%	35%	34%	34%
	Europe	175	177	186	189	194
	% Europe	26%	25%	25%	24%	23%
	Asia/Pacific	162	170	186	205	227
	% Asia/Pacific	24%	24%	25%	26%	27%
ROW		94	106	111	126	135
	% ROW	14%	15%	15%	16%	16%

Source: Radicati



Utilities and CityNext

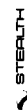
CityNext Solutions



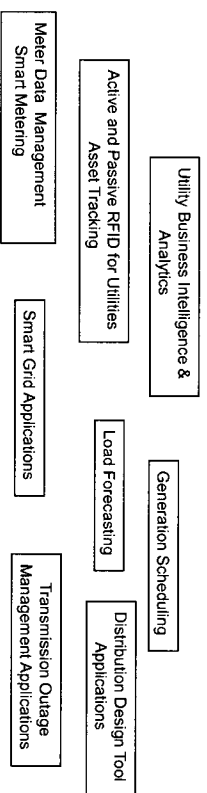
- Scalability & Performance
- Reduction in Cost, Complexity & Management Overhead
- Data Privacy, Compliance, Information Security & IP Protection
- Disaster Recovery & Business Continuity

STEALTH

Source: Microsoft, Stealth Software

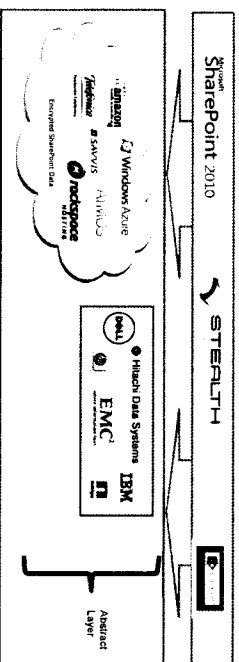


One secure, cost effective IT platform for the Utility Industry



Fixed Layer for all Applications

No Vendor Lock-in



STEALTH

Optimizing the Utilities behind the Scenes

STEALTH

Q&A

“Alternative Energy Integration with the Grid” ACC

Sayfe Kiaei
Professor of Electrical, Computer & Energy
Engineering
Director, Connection One NSF Center

ARIZONA CORPORATION COMMISSION
Commission Workshop on Emerging Technologies
Docket No. E-00000J-13-0375
DATE: Monday, July 28, 2014

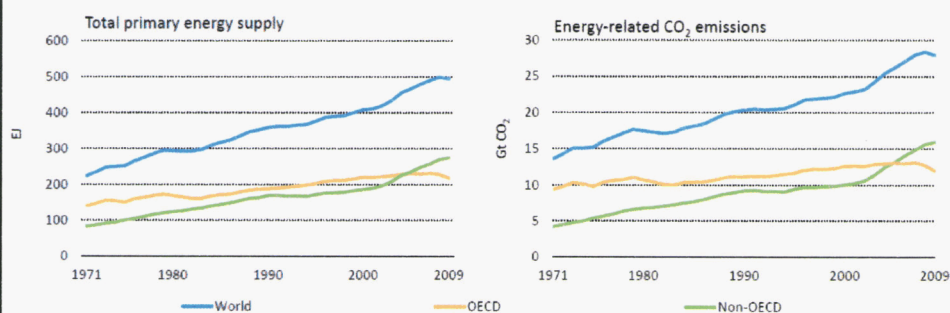
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1

Energy demand and emissions have doubled
in the past 40 years

ETP
2012



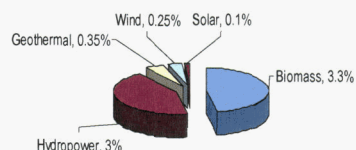
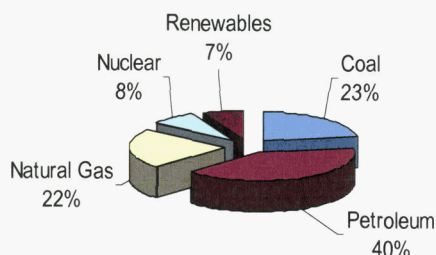
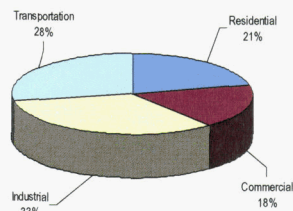
- CO₂ emissions from 14Gt to 30Gt
- Since 2005, non-OECD countries emit more than OECD

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Source: IEA statistics

Energy Today

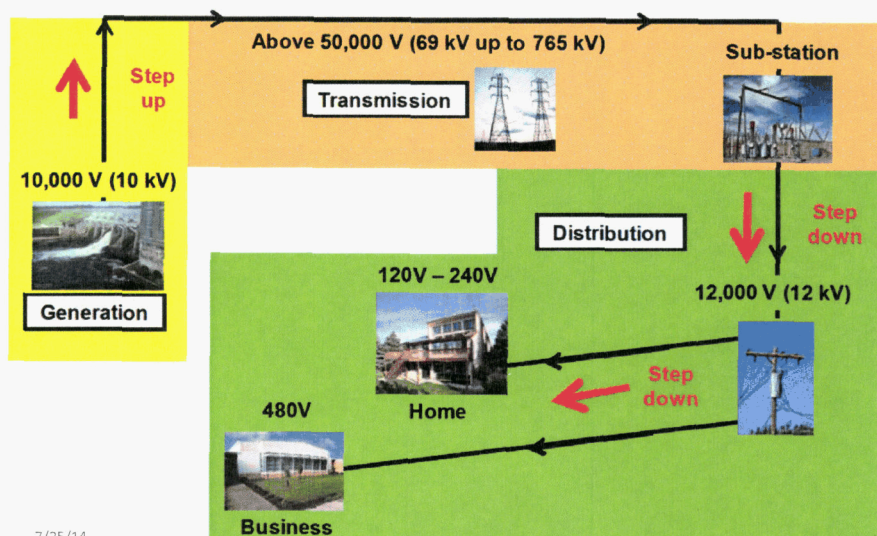
- 85% of U.S. energy consumption is still fossil fuels.
- 1/3 of U.S. energy needs are imported.
- Over 50% of the petroleum used in the U.S. is imported.



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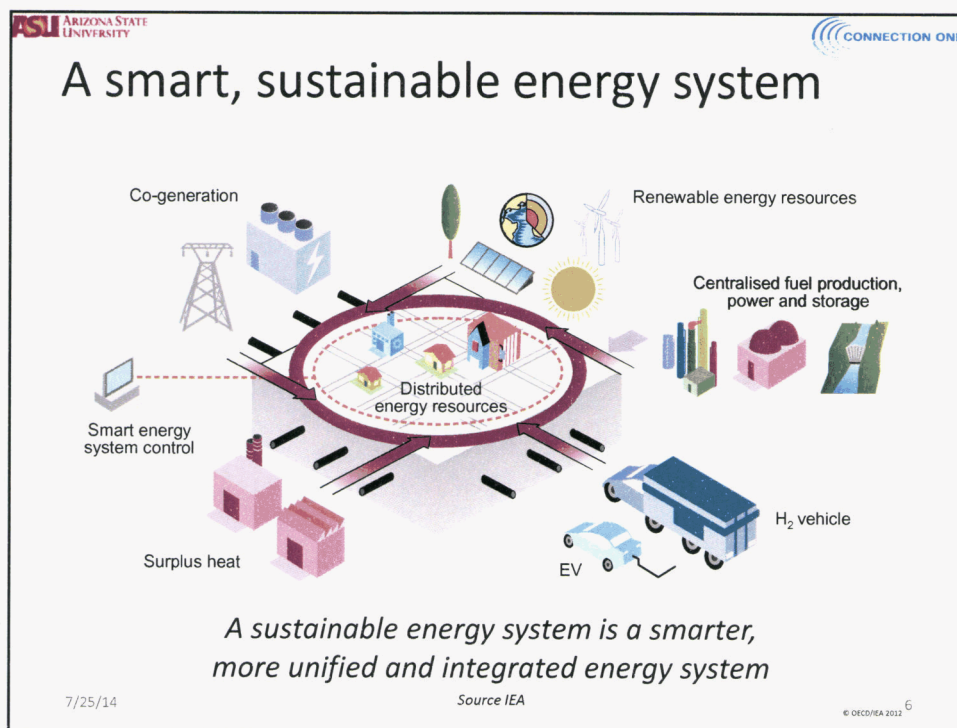
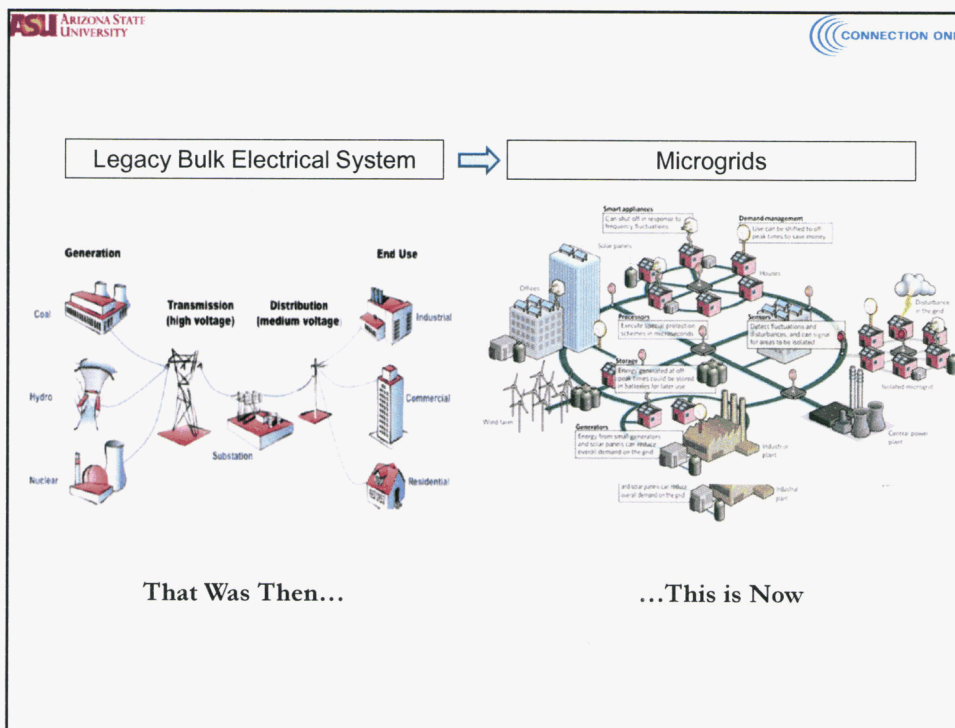
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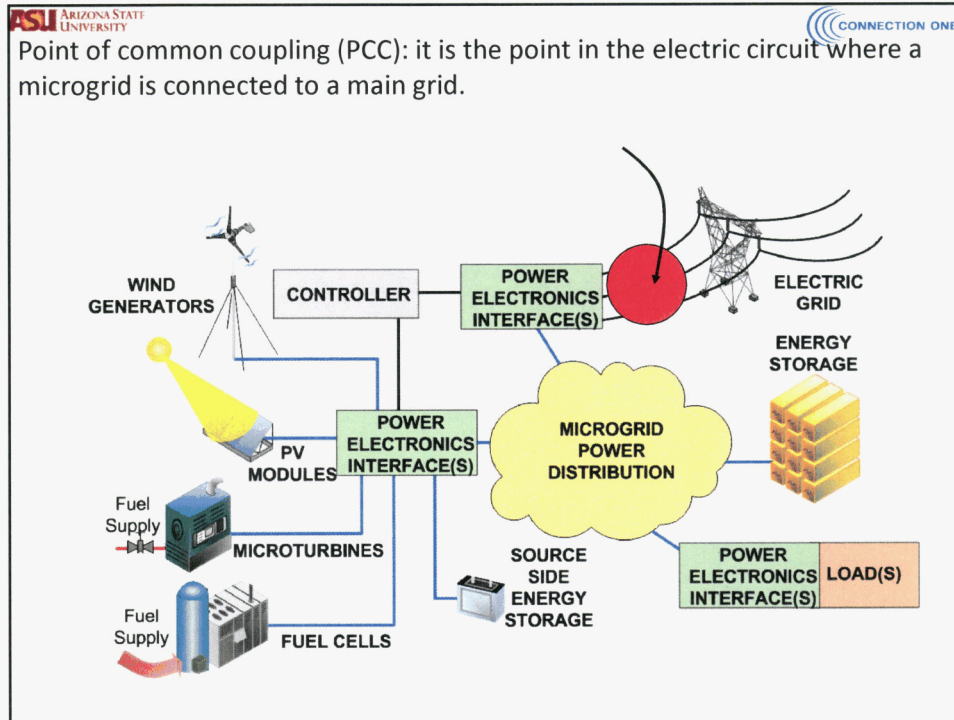
The Electric Grid



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Source: NREL



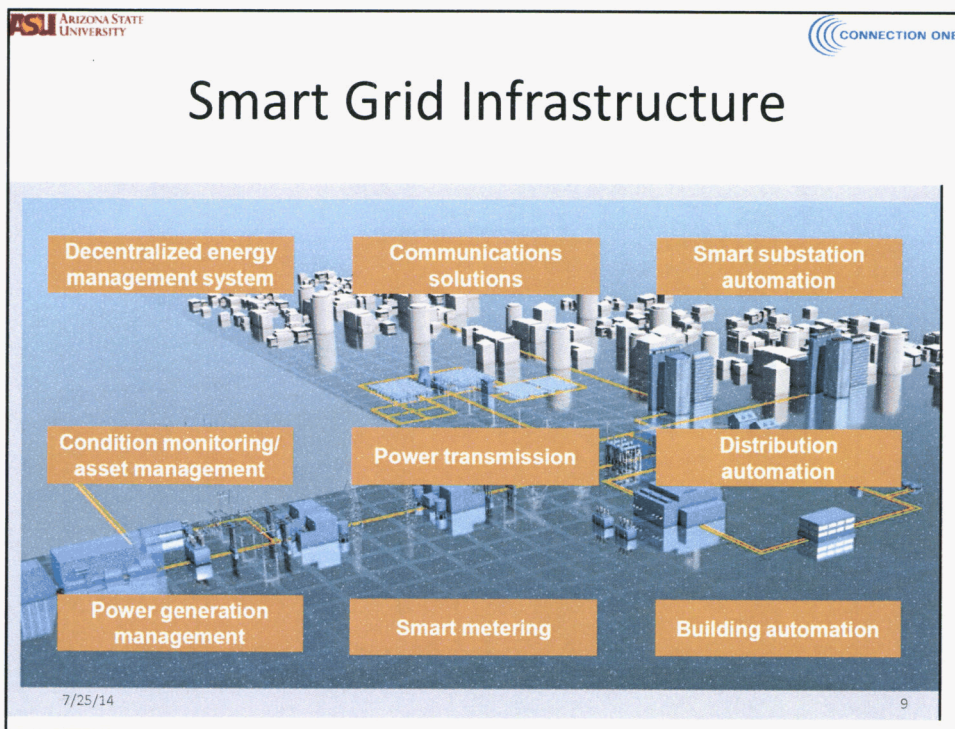


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Micro-Grid Motivation

- Availability
- Stability
- Storage
 - Grid connection may allow reducing the need for energy storage in the microgrid.
- Economics:
 - Planned with extra capacity
 - Extra Power capacity can be injected back into the grid
 - Grid Use at Night, Reduce fuel operational costs



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ASU research focus

- NSF & DOE QESST Center
 - ASU, MIT, Cal-Tech, Georgia Tech, U of Houston, U of Delaware, ...
 - Focus on Materials, PV, and Power Electronics
- PSERC
 - Power System Energy Research Center
 - Focus on Grid and Power System
- Connection One
 - Integrated System on a Chip

quantum energy and sustainable solar technologies

NSF/DOE ENGINEERING RESEARCH CENTER

Generating sustainable power by using photovoltaic technologies to harness today's unlimited sunshine

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Smart Grid R&D Needs

- Sensors
- Communication
- Adaptive Control
- Smart System

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NSF QESST Center

quantum energy and sustainable solar technologies

Thrust 1 - Terawatt Manufacturing

- Integration: Power Density, Cost, Size, Efficiency

Thrust 2 - Moore's Law for PV

- Reducing Power Electronics Feature Size

TestBed I: Student Lead Pilot Line

Testbed II: Advance Modules integration

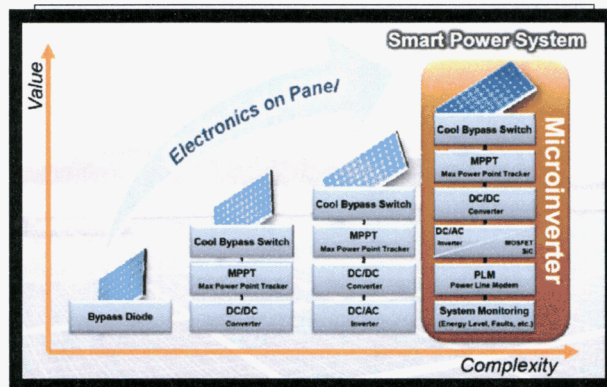
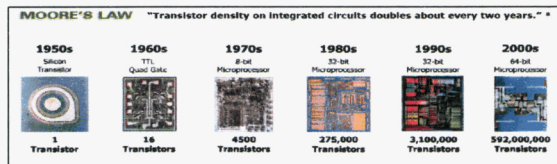
QESST RESEARCH CENTER

Integrated Electronics

Switches, Sensor, Converter, MPPT, Communication

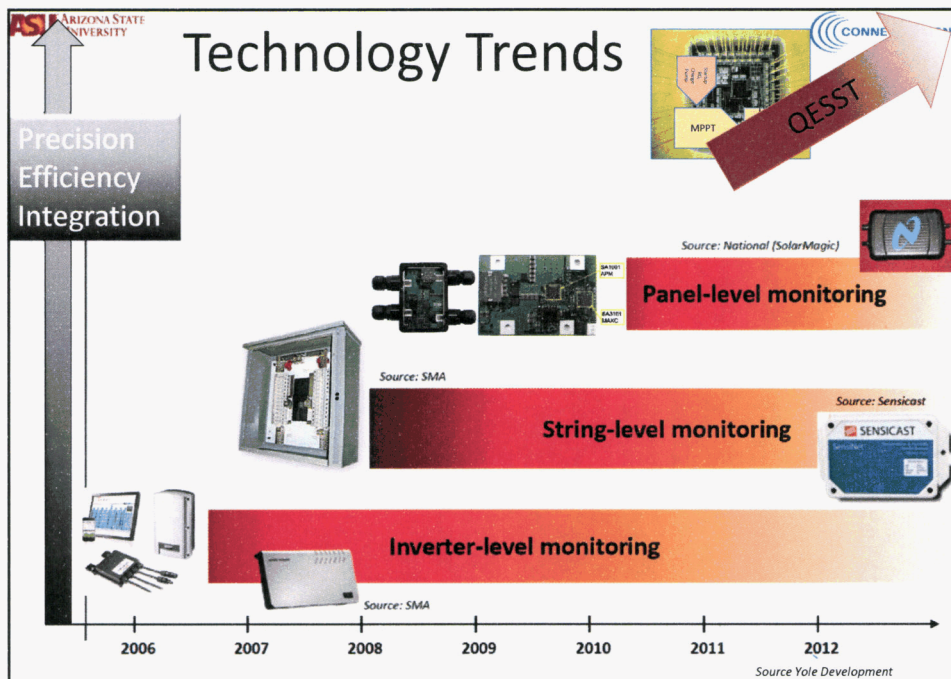
Technology Roadblocks:

- Sensors
- Switches (FET)
- Transformers,
- Inductors, Capacitors
- Control / Communication



Technology Trends

Precision
Efficiency
Integration



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Microinverters

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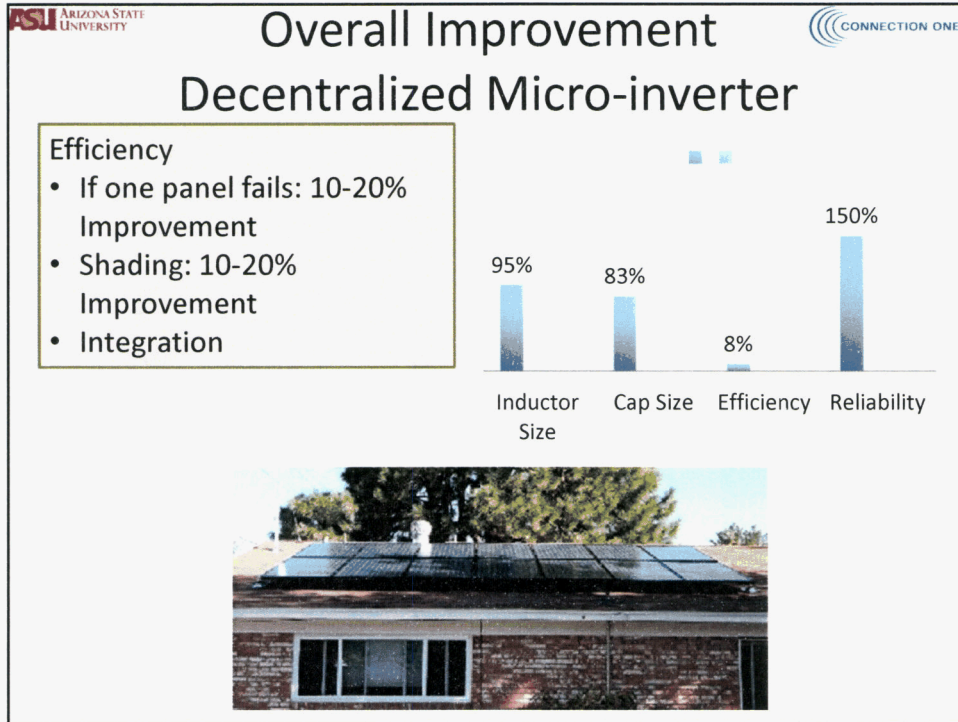
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Smart Grid Sensors – 2mmx2mm

2mm

2mm

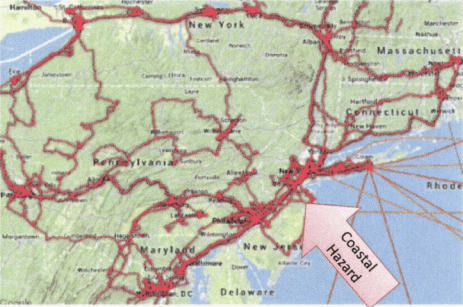
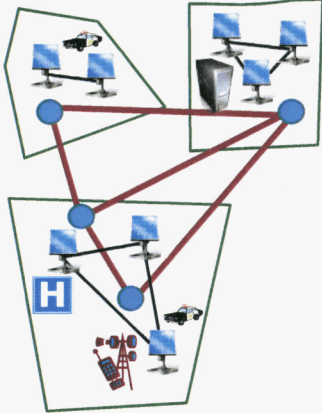


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Joint ASU & UA CIAN & QESST NSF Project Disaster Recovery Network & Energy System

Reconfigurable Optical Network & PV system For Disaster Recovery

- Sensor to Control system
- Intelligently optimize for maximum micro-grid efficiency

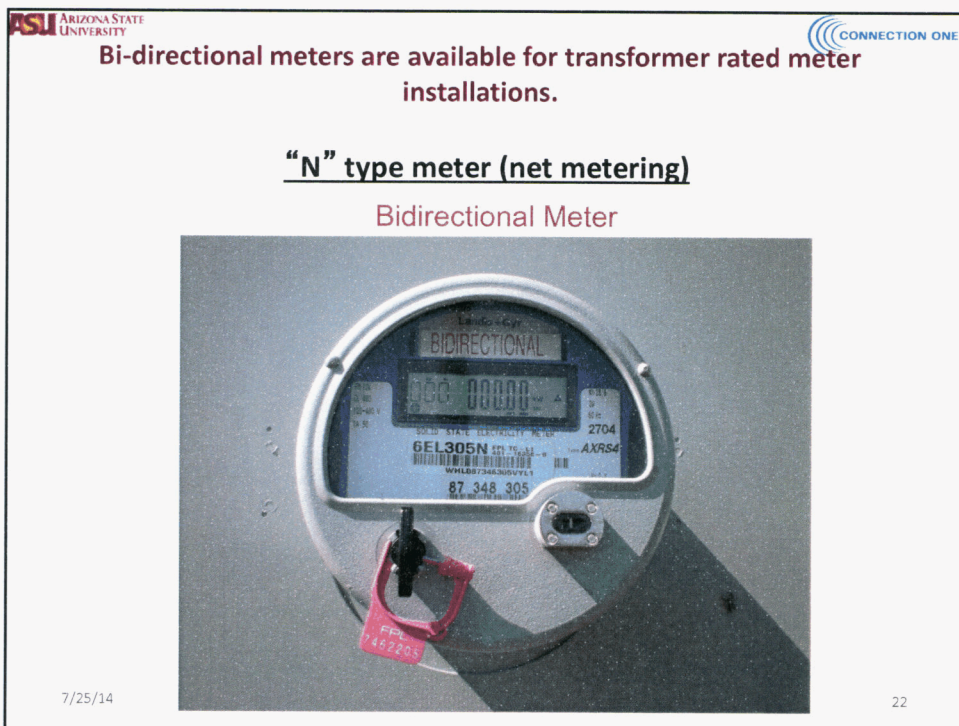
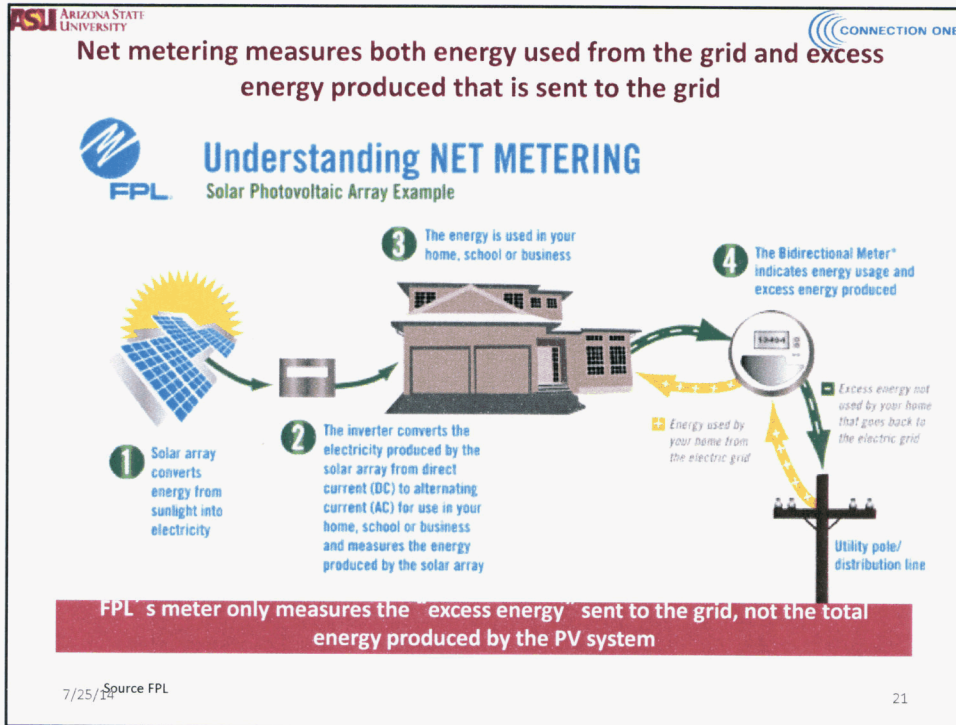
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QUESTIONS

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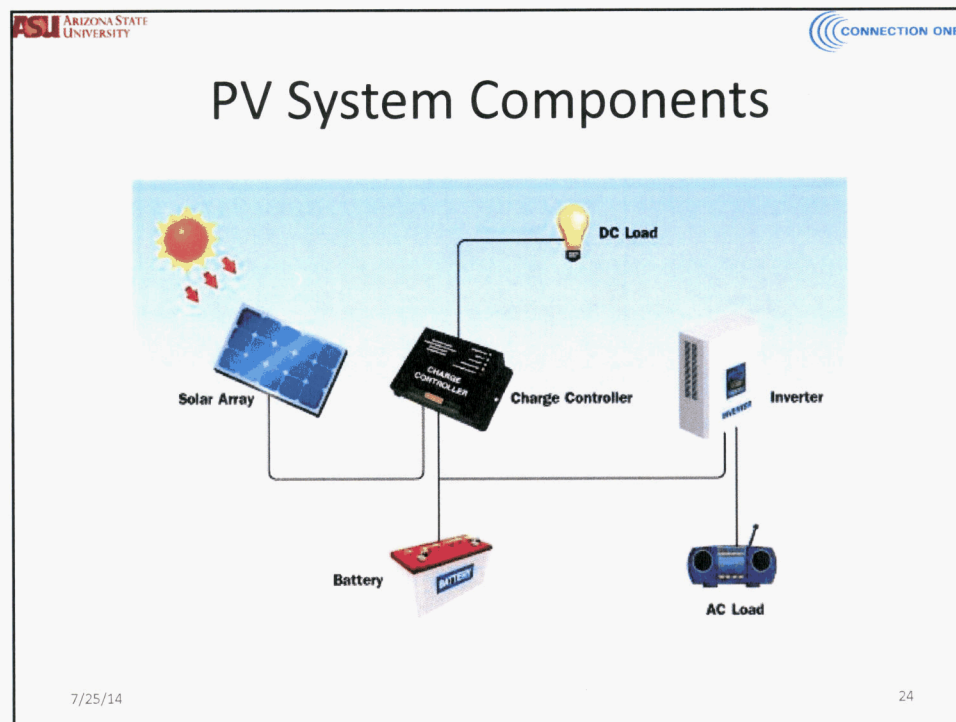
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Solar Technologies

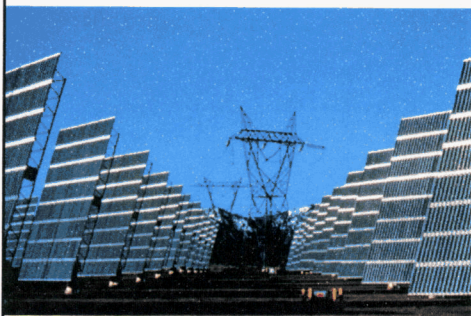
- Daylighting
- Passive Solar Heating
- Active Solar Heating
- Concentrating Solar Thermal
- Photovoltaics (PV)

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PV Array Fields



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Power Tower



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